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A review on the water and energy sectors in Algeria: Current forecasts, scenario and sustainability issues

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ABSTRACT

The water sector in Algeria has to date paid scant attention to the issue of climate change and is often unaware of its impact on future water resources. Studies will be needed to assess the impact and cost of climate change and draw up adaptation solutions.

Forecasts are not optimistic. Models for climate change indicate that rainfall could decrease by more than 20% by 2050, which would result in even greater worsening water shortages in different basins of Algeria. The construction of 70 dams planned will provide only small additional volumes.

The particular challenge for Algeria in the coming decades will be to adapt to a decrease in renewable water resources. The country will have to carefully manage these resources. Mobilization of non-conventional water resources (desalination and wastewater reuse) will be a strategic component of future water policy.

The development of unconventional resources and the management of water demand will increase more the energy consumption of the water sector. This consumption would reach nearly 12% of the country's consumption and must be integrated dice now in the country's energy forecasts.

More coordinated planning and action will consequently be required between the water and energy sectors if further aggravation of the water deficit is to be avoided.

Moreover, the revolution in renewable energy (wind and solar power) in terms of technological development and costs may help reduce the consumption of fossil fuels and ensure reserves for future generations by fostering decentralized renewable energy projects for alimentation of pumping stations.

Algeria has thus set itself by 2030 a share of renewable energy in the national energy balance of between 30% and 40%. The share of renewable power by 2023 will represent about 17% of installed capacity (5539 MW) compared to 4.74% in 2011 (540 MW).

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1. Introduction

Water is something of a rare commodity in Algeria. Renewable natural water resources are estimated at approximately 15 billion m^3 per year, that is approximately 404 m^3 per capita per year, near the threshold of 500 m^3 per capita per year, which is widely recognized as the scarcity threshold that indicates developing scarcity and underlying crises.

As part of its development program and in order to meet the needs expressed by users, Algeria has been working for some time on managing exploitation of its water resources. Since independence its policy in the face of water shortages and uneven distribution has been to ensure that water supply corresponds to the requirements of towns, cities and agriculture by constructing dams, developing large irrigation areas and setting up systems to supply drinking water to inhabitants. This has led to the creation of reliable infrastructure and competent agencies.

Nevertheless, the Algerian water sector is facing several limitations and problems which could, if not properly handled, limit the dynamic of economic growth that Algeria is looking for by launching a huge range of large-scale projects.

These limitations and problems relate primarily to decreased water resources due to the impact of climate change which has become a reality in Algeria and whose effects on our environment are already visible.

The future development of water resources depends on solutions characterized by high energy consumption, for example sea water desalination, the reuse of wastewater and the introduction of drip irrigation. Development of the water sector will therefore be closely tied to the development of the energy sector.

This sector must conduct a large-scale program of studies to understand the current and future impact of climate change, identify and quantify associated costs and its interactions with water and energy and specify adequate solutions for adaptation.

This report provides for Algeria an inventory on water resources, water demands and energy, presents strategic development of the sectors of water and energy, analyzes the interactions between water and energy (Fig. 1).

Fig. 1. The 05 hydraulics basins of Algeria.

2. Water in Algeria

2.1. Resources

Table 1 Across the country, water resources are as follows:

Table 2 From documents of Ministry of Water Resources (MWR), updated in February 2012

- 10 billion m^3 in the northern regions: 7.4 (surface water), 2.6 (underground resources);
- 5.37 billion m^3 in the Saharan regions: 0.37 (surface water), 5 (underground resources from Albian Water-table).

Structures in sedimentary basins of the Sahara are in favor of large and deep reservoirs which feed back to the rainy periods of the quaternary. The water-table of the continental Terminal (100–400 m depth), and the water-table Intercalary continental called “Albian” (1000–1500 m depth) contain significant reserves (30,000 to 40,000 billion m^3) but because their very low turnover (non renewable) the exploitable potential is very limited (5 billion m^3/year).

Table 1
Area and Population basins in 2011.

Basin	Oranie	Cheliff	Algérois	Constantinois	Sahara
Area (km^2)	77,169	56,227	47,431	44,348	2,018,054
Population M.inhab	6.9572	4.5026	13.2947	7.5572	3.9884

Table 2
Water resources.

Basin	Surface water (billion m^3)	Groundwater (billion m^3)	Total (billion m^3)
Oranie - Chott Chergui	0.65	0.6	1.25
Cheliff - Zahrez	1.71	0.83	2.54
Algérois - Hodna - Soummam	1.69	0.74	2.43
Constantinois - Seybouse - Mellegue	3.00	0.43	3.43
Sahara	0.37	5 Albian Water-table	5.37
Total	7.42	7.6	15.02

From documents of Ministry of Water Resources (MWR), updated in February 2012.

Table 3
Capacity of surface water by Hydraulic basin (2011) [1].

Hydraulic basin	Dams	Capacity (hm^3)	
		Initial	**Current**
1-Oranie Chott-Chergui	Beni-Bahdel. Meffrouch. Sidi-Abdelli. H.Boughrara. Sikkak. Sarno. Cheurfas II. Ouizert. Bouhnifia. Fergoug. Kramis	737	649.97
2- - Zahrez	Bakhadda. Dahmouni. C.Bougara. Merdja.S.Abed. Gargar. S.M.B.Aouda. Sidi-Yacoub. Oued-Fodda. Deurdeur Harreza. Ghrib. Boughzoul. O.Mellouk. Kt.Rosfa. S.M.B.Taiba. Prise –MAO. Kerrada	2294.9	1709.2
3- Algérois - Hodna - Soummam	Bouroumi. Ladrat. Meurad. Boukourdane. Keddara. Beni-Amrane. Hamiz. Lakhal. K'Sob. Ain-Zada.Taksebt. Tilesdit. TichyHaf. K.Acerdoune	1724.4	1693.2
4- Constantinois - Seybouse - Mellegue	H.Debagh. Ain-Dalia. O. Cherf. Zardezas. Guenitra. Beni Zid. Zit Emba. Cheffia. Mexa. F.E.Gueiss. Babar. F.ElGherza. F.Gazelles. El Agrem. Kt.Medouar. H.Grouz. B.Haroune. O.Athmania. Kissir. Boussiaba. Bougous	3141.3	3007.4
5- Sahara	DjorfTorba. Brézina	472.5	368.72
Total		**8370.5**	**7428.49**

2.1.1. Renewable and non-conventional water resource potential

2.1.1.1. Renewable water resources. Renewable water resources (surface water and groundwater) were estimated at around 16.5 billion m^3 for an average year on the basis of climatic series from before the 1980s. This estimate was revised down to around 12.2 billion m^3 taking into account the droughts experienced by Algeria since the 1980s, with a decrease in resources of around 25%.

Water availability dropped to under 447 m^3 per capita per year in 2012, which is significantly below the “scarcity threshold” of 1000 m^3 per year set by the UNDP. It is set to drop below 500 m^3 per capita per year, the “absolute scarcity” threshold.

2.1.1.1.1. Surface water resources. Surface water inflows reach several millions of cubic meters for the basins with the least water for average years: the Sahara Basins DjorfTorba-Bachar (350 hm^3) and Brézina- el bayath (122 hm^3), and billions of cubic meters for those with the most water: Beni Haroun -Mila (1000 hm^3) et Kissir-Jijel (680 hm^3) [1].

This runoff is largely due to rapid and powerful floods. They are generally recorded during an average estimated period of 20–30 days for the basins in southern Algeria and two to three months for the basins in northern Algeria.

Surface water resources are evaluated at approximately 8.376 billion m^3 for an average year (see Table 3). These water resources are characterized by high variability – the resources for nine years out of ten or four years out of five are significantly below this average. In a drought year, water inflow can drop to under 30% of this mean value. Managing the uneven distribution of water resources in time and space has involved the construction of large dam reservoirs for storing the inflow from wet years to be used in dry years and transferring water from regions with surplus water to regions with water shortages in order to encourage balanced economic and social development across the whole of Algeria.

2.1.1.1.2. Groundwater resources. Potential groundwater resources are estimated in 2011 at around 2,602,822,992 m^3 per year, of which 794,213,270 m^3 per year comes from irrigation water returned via surface water in particular [2] (Table 4).

2.1.1.2. Non-conventional water resources. Non-conventional water resources offer a significant water resource potential in Algeria. They involve reusing wastewater, artificial recharge of groundwater and freshwater production through the desalination of sea water or demineralization of brackish water. The Algerian National Water Resources Strategy estimates the volume of water that could be exploited from non-conventional water resources at over 2 billion cubic meters.

2.1.1.2.1. Wastewater potential [7]. Park of sewage treatment plants In operation:

- Total = 145
- Total treatment capacity = 12,000,000 EQH
- Volume = 800 hm^3/year

Table 4
Potential groundwater of northern Algeria [2].

BV	Name of hydrogeological unit	Area (km^2)	Renewable resources (hm^3/y)	
			Average year	Dry year
Water-tables having been modelised				
2b	Water-table of Mitidja	1492	307.2	100.02
05	Chott Hodna	7127	256.4	32.14
11	Plain of Sidi Bel Abbes	1211	133	3.4
15	Upper and Middle soummam	206	63	12.28
01	Plain of Ain Ouassara	2811	67.9	5.14
04	Basin of Mostaganem	582	50.4	4.05
11	Plain of Eghriss nappa of Mascara	834	42.1	3.32
15	floodplain of low Summam	92	21.7	12.8
08	Chott Ech Chergui	17032	55	8.72
07	Plain of Remila Khenchela	2679	34.5	14
07	Plain of ElMader	1612	28.4	8.48
12	Plain of Tebessa	1026	26	3.53
06	Basin of Chéria	847	24.7	14.3
17	Basin of Zahrez	3863	18.7	3.97
16	Plain of Maghnia	231	18.2	1.21
04	karstic water-table of Murdjajo	302	14.2	1.67
04	Plain of M'leta	760	17	3.07
	Subtotal of modelised water-tables		**1178.4**	**232.1**
Water-tables having been quantified				
03	Plain of Annaba	757	86	15.29
01	West Valley of Abd Et Taht	2024	37.8	6.24
10	Alluvium of Oued Kebir	61	32.5	12.57
2b	Lower Valley of Sebaou	73	30.1	14.61
2b	High Valley of sebaou	65	26.1	12.64
09	Lower Valley of Isser	74	23.3	6.54
08	Chott Gharbi	14820	22	6.19
03	Oued Nil	23	18.9	7.43
01	Alluviale Plain of low Chellif	824	17.3	8.64
14	Plain of Guelma	265	16.4	7.33
03	massive dune of Tichi Cap Aokas	7	16.4	0.19
01	Plaine Alluviale du moyen Chellif	215	16	4.78
01	Alluviale Plain of top Chellif	459	16	8.83
03	Oued Djendjen	49	14	6.49
01	limestone Djediouia-Oued Fodda	220	12	2.6
03	Plain of l'Oued Kebir/Guerbes	321	11.1	6.84
03	alluvium of Oued Agrioun	20	11	2.32
01	Plain of Ksar Chellala	446	10.2	0.86
06	Kef Gharbi	990	6.7	3.35
09	Valley of middle Isser	38	5.7	2.95
2b	Oued Hachem	23	3.8	0.35
03	Plain of Collo	37	3	2.15
2b	Oued Nador	10	2.4	0.16
01	Djebel Doui		2.3	0.75
2b	Oued Boudouaou	12	1.4	0.48
03	Oued Mencha	131	1.2	0.45
03	Oued Zhour	160	1.1	0.34
01	Djebel Ben Hammade	109	0.6	0.05
	Subtotal of quantified water-tables		**630.6**	**175.57**
	Total of modelised and quantified water-tables		**1809**	**407.67**

In progress:

- Total = 106
- Total capacity of treatment to the end of 2012 = 7965058 EQH
- At the end of the current program in 2014 = 1.2 billion m^3/year

2.1.1.2.2. Sea water desalination. Desalination has overcome technological difficulties and is now a viable, economically competitive and technologically achievable alternative for drinking water or agriculture and the irrigation of some profitable crops. The reverse osmosis technique now used involves passing sea water at a pressure of 70 bars through a special membrane to produce freshwater. This technique has made a significant contribution to reducing operational costs, such that it has been adopted by a large number of countries as the method of choice.

- Desalination is now technically feasible. It provides a reliable resource that can be assessed in advance, making it possible to plan investments and construction projects better;
- Desalination facilities can be built using a BOOT (Build, Own, Operate and Transfer) system;
- Desalination facilities can be built quickly (12–24 months including the design stage).

Algeria is only just starting to produce freshwater by desalination or demineralization (2005). Overall production capacity is already around 2,310,000 m^3 per day.

Sea water desalination may be the most appropriate solution to the situation faced by many regions in Algeria to plug the gap between water demand and supply.

The national strategy estimates the contribution of sea water desalination at approximately 1000 Mm^3 by 2030 [12] (Table 5).

2.1.1.2.3. Brackish water. In Algeria, around a quarter of groundwater is, either in whole or in part, brackish water. This water is mostly situated in the country's desert and semi-desert regions.

Exploitation of brackish water resources began in 2000.

The volume of brackish water mobilized is estimated at 510,160 hm^3/year whose 160 hm^3/year are used to satisfy the drinking water supply.

Twelve (12) stations are operating in the provinces of Tlemcen, Oran, Tizi Ouzou, Bejaia, Illizi, Biskra, Ouargla, Medea and Ain Defla. The production of drinking water is 24.2 hm^3/year [4].

Also, 241 hm^3/year of brackish water will demineralized from a mobilized volume of 464 hm^3 through 35 stations which are actually under study and work (included in different programs). The overall capacity of stations is 91.5 hm^3/year. Overall throughput mobilized in upstream exceeds 428.9 hm^3/year.

The situation is as follows [4].

- In Study: 06 stations (Tamanrasset 4, El Oued 2) With 04 station whose studies were completed (Tamanrasset 2 and El Oued 2);
- Study and réalisation: 01 station (Bechar);
- In Works: 12 stations (10 Ouargla, El Oued and Tamanrasset (ADE));
- Launching work in Progress: 02 station of ADE (Tindouf and Illizi);
- Installation of Mono-Blocks: 15 stations (El Oued) whose: 01 station completed and commissioning (Réguiba C.).

Table 5
Stations of desalination of seawater [3].

Region	Localization	Capacity (Thousand m^3/day)	Status
West	Arzew/Oran	90	August 05
	Souk tleta/Tlemcen	200	May 11
	Honaine/Tlemcen	200	July 12
	Mostaganem	200	Sept 11
	Sidi djelloul/Ain temouchent	200	Dec 09
	Mactaa/Oran	500	Work in progress
Center	Hamma/Alger	200	Feb 08
	Cap djinet/Boumerdes	100	August 12
	Fouka/Tipaza	120	July l 11
	Oued sebt/Tipaza	100	SDEM not launched
	Tenes/Chlef	200	Work in progress
East	Echatt/Tarf	100	SDEM not launched
	Skikda	100	March 09
Total		**2310**	

2.2. Current use of water resources

Since the 90s [1], Algeria has adopted an appropriate policy of water resources development focussed on the construction of dams which has provided drinking water supply security for all the towns and cities in the country and made it possible to develop approximately 1,234,985 ha of irrigated land, of which approximately 228,787 ha are part of large irrigated areas [5].

This supply policy means water infrastructure of 84 large dams (19 under construction), a storage capacity of 8.9 billion m^3 (96 dams planned for 2016), 10 water transfer structures and large structures for abstracting groundwater are now available (Table 6).

This water infrastructure has been designed and built in order to provide an overall volume in the region of 10 billion m^3 in a year with average rainfall year.

This infrastructure provides significant benefits to the Algerian economy. This can be seen in the strategic role of the contribution of the sectors associated with dams to the country's water and food security, the growth in farmers' incomes, employment, the opening up of different regions and access to various public services (drinking water, etc.).

2.2.1. Drinking water

Over the last three decades, the Algerian Government has operated an ambitious policy of securing drinking water supply to all in towns and cities, reaching a coverage rate of 95% in rural environments.

The drinking water production capacity for urban areas multiplied by 2.5 between 1999 and 2012, reaching 3.1 billion m^3 per year [6].

Everyone has access to drinking water in urban areas. The urban population served now exceeds 36 million inhabitants, 95% of whom are supplied by individual connections.

Table 7 below summarizes the progress made in the drinking water sector.

2.2.2. Sanitation and wastewater treatment

The sanitation sector in Algeria lagged significantly behind until 2000, due to the low priority given to wastewater management issues and operator regulation.

As part of the Millennium Development Goal associated with sanitation, Algeria produced a National Program for Liquid

Table 6
Major Transfer Systems (North–North/Nord-South/South–South).

Transfer systems	Destination (Wilayas)	Capacity of treatment (m^3/day)	Population (M inhab)
Beni Haroun	Constantine-Mila-Jijel-Batna-Khenchela	440,000	4
Teksebt	Alger-Tizi Ouzou	600,000	5
Mostaganem-Arzew-Oran (MAO)	Mostaganem-Oran	560,000	1.5
Koudiat Aserdoune	Bouira-Médéa- Tizi Ouzou-M'sila	346,000	2
Tichy Haf	Béjaia	120,000	1.5
Mexa	El Taref-Annaba	173,000	1.5
Insalah-Tamanrasset	Tamanrasset	100,000	0.45
Sétif high plains			
East lane	Sétif	136,000	0.75
West lane	Sétif	191,000	1.107
Chott El Gharbi	Tlemcen-Naama-Sidi Bel Abbes	71,000	0.25
South- Highlands	Djelfa-M'sila-Tiaret	350,000	6.15

Table 7
Drinking water sector indicators [6].
Source: Note PNE. Jan 2013.

Indicators	1999	2011	2012
Linear drinking water systems (km)	50,000	102,000	105,000
Connection rate	78%	94%	95%
Staffing (liter/day/capita)	123	170	175
Water production (million m^3/year)	1.25	2.9	3.1
Frequency distribution			
daily	45%	73%	75%
1 days per 2	30%	17%	17%
1 day per 3 and more	25%	10%	08%

Sanitation and Wastewater Treatment (PNA) in 2005. The result of the investigation into the sewage system at the end of the second half of 2012 reported 43,000 linear network Kilometers in service. The national average connection rate calculated on the basis of the average connection rate of 48 provinces is 87%, for a total volume of waste water discharged of 1.2 billion m^3/year [7].

Since its launch, a significant quantitative step has been made in terms of numbers of sanitation and wastewater treatment projects and the volume of investment in this sector. The Government's political will was implemented with increased financial resources allocated to the PNA under the Algerian Finance Acts, and contributing partners showed a keen interest in this program and agreed funding and significant assistance to get it launched.

The impact of this program can be summarized as follows:

- Reduced pollution on the Mediterranean and Atlantic coast, since almost all wastewater from towns and cities discharged into the Mediterranean Sea and the Atlantic Ocean will be treated;
- Almost all wastewater discharged from towns and cities into watercourses will be treated. Treatment of this wastewater and taking into account the environmental aspect in water resource management will lead to an improvement in surface water quality;
- Increasing the water potential which could be used in the development of irrigation. The National Water Resources Strategy, defined in 2009, estimated this potential at approximately 1.2 billion m^3 per year in 2014 to be reused in watering golf courses and green spaces as well for irrigation of crops that are suited to it.

2.2.3. Irrigation [8]

In the light of the exploitable water potential, the potential land area for sustained irrigation identified during the 1960s is evaluated at 164,000 ha which represents approximately 1.94% of Algeria's total useful agricultural area of 8,445,490 ha [9]. Currently, the area exceeds 1,470,000 ha which 62% by gravitation, 22% by spraying, 15% mode localized irrigation (drop by drop) and 0.9% by tank in the north of the country (Table 8).

Water from all dams and groundwater for the irrigation in 2011 are estimated to average around 8.6 billion cubic meters per year whose 8.1 billion for MSSI and 0.5 billion for LSI (Table 9).

This supply level was over 50% less than that set out in the planning.

This decrease was compensated for by overuse of groundwater. The vast majority of Algeria's aquifers are overused and their levels are several meters down per year. The volume of water overused is evaluated at approximately 1092 Mm^3 per year (Table 10).

This alarming deficit of approximately 4 billion m^3 per year, of which approximately 1 billion m^3 comes from overuse of groundwater, is the direct consequence of the impact of climate change.

Table 8
Irrigated area (MSSI+LSI) in hectares.

	Type	1962	1999	2011	2014
Irrigated area (ha)	**MSSI**	120,000	350,000	923,841	1,200,000
	LSI	105,500	156,250	228,787	270,000
Total		225,500	506,250	1,152,628	1,470,000

LSI: Large scale irrigation.
MSSI: Medium and small scale irrigation.

2.2.4. Hydroelectric power generation

The share of hydro capacity in the park of electricity production is 5% or 270 MW only.

This low power is due to the insufficient number of water sites (dams) and the non-use of all existing hydraulics sites (Table 11).

2.3. Future water demand

Overall, water demand for all use sectors is evaluated at approximately 20 billion m^3 in 2030, distributed as follows (Table 12);

2.3.1. Water demand for the supply of drinking and industrial water

Forecasts for future domestic water use are based on population growth, rural to urban migration and water demand per capita projections.

Overall, drinking, industrial and tourist demand forecasts for the whole of Algeria by 2030 are evaluated at 3.5 billion m^3 (Table 13).

2.3.2. Irrigation water demand

Agricultural water demand corresponds to the potential irrigation water needs evaluated on the basis of recommended rotations and theoretical water needs of crops.

This water demand has been evaluated in the PDAIREs at approximately 8.5 billion m^3 including approximately 0.4 billion m^3 for the areas served by large-scale hydropower dams (including water demand for areas not equipped for irrigation), 8 billion m^3 for small- and medium-scale hydropower dams and around 0.1 billion m3 for private irrigation (Table 14).

2.4. Resources-demand balance

The current balance of water supply and demand is analyzed by river basin. It involves comparing water resources and demand in order to establish a representative picture of the water situation at a given date. The assumptions taken into account can be summarized as follows:

- Water demand taken into account corresponds to the demand expressed by users, mainly in the drinking water and irrigation sectors;
- The water resource value taken into account in this balance corresponds to the volume of water regulated by the dams and water abstractions made directly from rivers and groundwater, despite the fact that the latter significantly exceeds renewable levels.

2.4.1. Surface water projection

The planning studies performed allow by 2030 for the construction of around seventy dams across all river basins (139 dams in total) in order to secure supply for Algeria's water needs. The volumes of exploited and exploitable surface water are taken from

Table 9
State details of Large scale irrigation (LSI) [10].

	Basins	Perimeters	volume allocated 2009 (hm^3)	volume allocated 2010 (hm^3)	volume allocated 2011 (hm^3)
National office of Irrigation and Drainage (NOID)	**Oranie**	**Habra**	18	18	10
		Sig	20	13	13.5
		Brezina	2	1	01
	Cheliff	**Mina**	32	28	30
		Bas Cheliff	10	23	34
		Moyen Cheliff	43	56	60
		Haut Cheliff	58	54	50
		Amra-Abadia	43	49	40
		Dahmouni	5	10	11
		Bougara	1	0.7	01
		M'ghila	0	0	0
	algérois	**Hamiz**	10.50	11	11
		Mitidja Ouest	20	23	30
		Sahel Algérois	2.50	3	03
	Constantinois	**Bounamoussa**	23	25	20
		Saf saf	21	12.5	10
		Guelma	35	35	35
		Zit Emba	5	5	5
		Sadrata - Ksar Sebahi	0	3	4
		Jijel	0	1	2.5
	Sahara	**Oued R'hir**	122	115	99.55
		Outaya	9	13.5	13
OPI Wilaya	**Tlemcen**	**Maghnia**	7	8	10
	M'sila	**K'sob**	12	10	09
	Bouira	**Arribs**	6	3	4.5
	Béchar	**Abadla**	70	28	00
Total operating perimeters			575	549	507

Table 10
Campaign Irrigation MSSI [10].

Nature of water resources	2009		2011	
	Nbre	Area	Nbre	Area
Small Dams	96	4019	86	5938
Hill reservoirs in operating	273	6090	309	7663
Drillings	57,826	455,322	62,967	486,806
wells	133,333	293,253	144,050	316,198
Over water	9936	68,012	9247	75,637
Sources	6288	75,509	5939	19,043
Others	934	18,748	1115	12,558
Total		**920,953**		**923,843**

Table 11
Hydroelectric power installed in Algeria.

Hydro plant	Installed power (MW)
Darguina	71.5
Ighil Emda	24
Mansouria	100
Erraguene	16
Souk el Djemaa	8085
Tizi Meden	4458
Ighzernchebel	2712
Ghrib	7000
Gouriet	6425
Bouhanifia	5700
Oued fodda	15,600
Beni behde	3500
Tessala	4228
Totale	**269,208**

the Algerian National Water Debate report, the National Water Plan study and specific studies performed for dam construction projects.

Table 12
Changes to future water demand not taking climate change into account in Mm^3 [11].

Use sector	2011	2030
Drinking (urban and rural) and industrial water	2900	3500
Not served industry and tourism	0.125	0.2
Irrigation water	8600	15,400
Hydroelectric power	–	–
Total excluding not served industry and tourism	11,500	18,900
Total including isolated industry and tourism	11,500.125	18,900.2

Table 13
Current Needs of drinking water per basin (Mm^3).

Basin	Volume (Mm^3)	Satisfaction rate %
Oranie - Chott Chergui	396	52.5
Cheliff – Zahrez	558	78
Algérois - Hodna – Soummam	927	89
Constantinois - Seybouse – Mellegue	794	83
Sahara	225	57
Total	2900	76.75 (Average)

The planned dams are intended to be built increasingly far away from the place of water use, and their construction is increasingly complex and costly in both technical and economic terms. They will make it possible to exploit additional water in the region of 5 billion cubic meters. These projects primarily involve increasing irrigation to areas already equipped for irrigation, and will not make any significant difference to water balances. Table 15 shows the volume may be raised by the construction of new water dams.

Exploiting this additional water as a resource would require, according to the National Water Resources Strategy, the construction of new water transfer project.

2.4.2. Groundwater projection

The groundwater projection takes into account the impact of the measures in the National Water Resources Strategy on inflow and outflow. This mainly involves:

- Implementing the irrigation water conservation program, which will lead to a significant reduction in water abstraction and irrigation returns;
- Use of surface resources to replace groundwater abstraction. A volume of around 100 Mm^3 abstracted for drinking water from groundwater will be replaced by surface water (100 Mm^3 per year by 2025);
- Artificial recharge of groundwater. The National Water Resources Strategy evaluated this recharge at around 200 Mm^3 per year by 2030, with around 100 Mm^3 from treated wastewater;
- Strengthening of the monitoring and sanctions system for over-users and the restriction of pumping from groundwater (revised pricing framework, removal of subsidies providing incentives to overuse, implementation of measures for the setting up of protected and prohibited areas, etc.)

These measures to improve groundwater recharge and especially reduce water abstraction will make it possible to contain demand, set to vary very little between 2013 and 2030, and especially between 2030 and 2050. In these conditions, groundwater balances will slowly even out, mainly by a decrease in outflow by natural outlets.

The groundwater projection takes into account changes in irrigation return water which will be realized by implementation of the National Water Conservation Program, changes in outflow realized by changes in irrigation return water and the ongoing decrease in groundwater levels, and changes in water abstraction realized by the National Water Conservation Program and the strengthening of the control system. Table 16

2.4.3. Non-conventional water resources projection

Non-conventional resources primarily consist of artificial groundwater recharge, sea water desalination and treated wastewater.

The Algerian National Strategy for Development of Water Resources gives a significant place to the exploitation of non-conventional water resources.

This strategy estimated the proportion of this resource at around 1.624 billion m^3 per year, of which 824 Mm^3 from sea water desalination and around 800 billion m^3 from wastewater.

The forecasts are levels in 2030 to nearly 3 billion m^3. This water potential is intended to be used for watering green spaces and sports fields and developing irrigation around urban areas.

Table 17 presents the anticipated contribution of desalinated sea water and treated wastewater.

3. Electricity in Algeria

3.1. Energy context

The Algerian population is around 38.5 million people and is expected to reach 45 million by 2030; more than 60% live on the coastal area. The population growth and rapid urbanization have an impact on the demand for energy and the environment. The total energy consumption of Algeria in 2012 was about 50.9 million tons of oil equivalents (TOE) and should increase to 91.54 million TOE in 2030 [16]. It is expected to increase by 3.3% per year, due to significant development needs and for universal access to energy.

The trend scenario, which extrapolates current policies, indicates that energy consumption in the country remains mainly based on fossil fuels which will still account for about 80% of demand in 2030. Oil will remain the dominant energy source well

Table 14
Irrigation water needs per basin in Mm^3.

Basin	LSI		MSSI		Total	
	Demand	Supply	Demand	Supply	Demand	supply
Oranie -	97.5	34.5	784.59	685.80	882.09	720.30
Chelif	374	226.5	1985.96	1885.66	2359.96	2112.16
Algérois -	405	57.5	2269.59	1998.86	2674.59	2056.36
Constantinois -	158	76.5	3350.85	3158.82	3508.85	3235.32
Sahara	130	112.5	424.59	370.86	554.59	483.36
Total	1164.5	507.5	8815.57	8100	9980.07	8607.5

Table 15
Changes in volumes of exploitable surface water in Mm^3.

Bassin	2011	2030
Oranie - Chott Chergui	649.97	In study
Cheliff - Zahrez	1709.2	In study
Algérois - Hodna - Soummam	1693.2	In study
Constantinois - Seybouse - Mellegue	3007.4	In study
Sahara	368.72	In study
Total	**7428.49**	**12,000**

Table 17
Forecasting of unconventional waters for 2030 per basin in Mm^3 [22].

Basin	2011		2030	
	Wastewater	Desalination	Wastewater	Desalination
Oranie	153.33	383.432	In study	In study
Cheliff	99.23	111.325	In study	In study
Algérois	293	276.743	In study	In study
Constantinois	166.54	053.400	In study	In study
Sahara	87.9	0	In study	0
Total	800	824.900	2000	1000

Table 16
Balance Sheet projected groundwater without considering of the climate change.

Basin	Exploitable and sustainable groundwater resources		Groundwater demand		Balance	
	2011	2030	2011	2030	2011	2030
Oranie- Chott Chergui	594	410	780	420	−186	−10
Cheliff Zahrez	830	800	1150	785	−320	+15
Algérois Hodna Soummam	740	640	780	580	−40	+60
Constantinois - Seybouse Mellegue	439	350	480	300	−41	+50
Sahara	700	700	5313	6000	−4613	−5300
Total	3303	2900	8503	8085	−5200	−5185

it is losing share for the gas in electricity generation. Gas demand will increase and account for 40% of global energy demand. Oil demand will continue to grow by 1.7% on average, reaching 12% of the energy mix by 2030.

In 2030 in the case of trend scenario, will dominate the fossil energy, oil and gas mainly. However, it should be recalled that Algeria does not have endless resources; it holds only 4% of proved global gas reserves. Prospective studies indicate that oil production in Algeria is expected to increase by only 20% in twenty years, while gas production is expected to double. Algeria, in the current state of knowledge on reserves could become energy importers and much more of Oil [17].

3.2. Hydrocarbon resources

We recall the difference between the concepts of reserves and resources. The ultimate resources represent what the nature has bequeathed to us, they are estimated for Algeria to 10.6 billion m^3 of initial proved reserves for oil (Fig. 3). Proved resources are the part that we are able to extract physically, this part is about 60% of ultimate resources (7.6 billion m^3).

Recovered reserves correspond to the volumes of hydrocarbons contained in the production oilfields which we are able to extract with the technical and economic conditions of the moment, this part is about 2.6 billion M^3 minus 1.4 billion M^3 already produced.

It remains a last category, oils located in the remaining oilfields (Probable and possible) yet to be discovered, oils that could be extracted through recovery technologies and unconventional oil (heavy oil, extra heavy…) see (Figs. 2 and 3).

3.3. Hydrocarbon reserves

Referring to the most famous statistical review of Schlumberger, the evaluation of proved hydrocarbon reserves of Algeria in late 2007 was 5.6 billion TOE including:

- Oil reserves estimated at 1.5 billion tons (12.3 billion barrels)
- Gas reserves estimated at 4.1 billion TOE (4500 billion m^3), which represents 4% of global gas reserves. Thus Algeria ranks fifth in the world for natural gas reserves.

These data represent only the volumes of Oilfield discovered or in production, these data could increase thanks to future

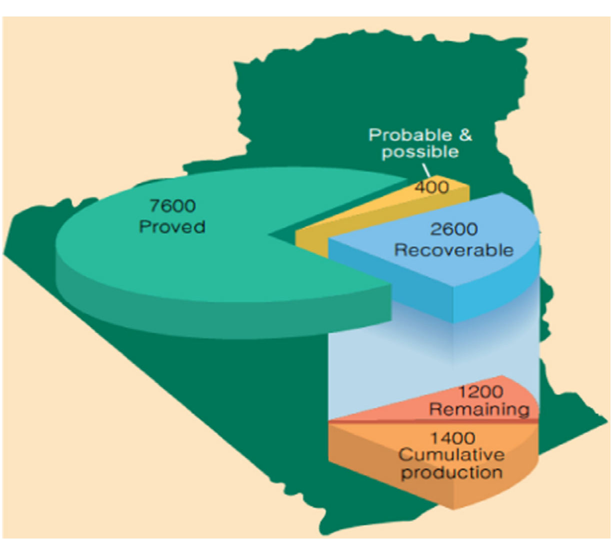

Fig. 2. Oil Statistics in Algeria (Billion m^3 EP) [17].

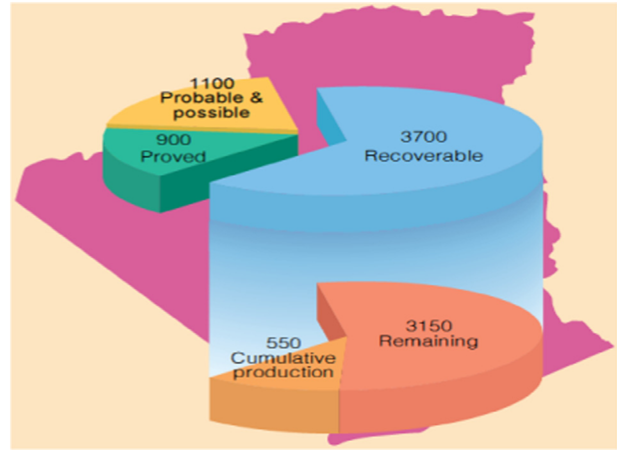

Fig. 3. Statistics Gas in Algeria (Billion m^3 EP) [17].

discoveries and technological innovations that will pass resources to additional reserves.

The life expectancy of reserves in Algeria is about 35 years from 2008, measured by the ratio (reserves/production). This ratio is static and does not take into account future production (the prospects for new discoveries), it provides the time to associate allocations of reserves to government policy (Table 18).

3.4. Energy demand

The energy bill (consumption) of Algeria as a whole has been multiplied by 2.5 in 10 years, from 20.5 in 2002 to 50.9 Million - TOE in 2012.

Fig. 4 The distribution of energy consumption in 2012 is shown by Figs. 5 and 6 according to source of energy and activity sector respectively.

The structure of the final consumption shows the importance of the share of petroleum products (38%) and natural gas (26.7%).

In the absence of a rigorous energy efficiency policy, by 2030, primary energy demand will be between 120 and 130 MTOE. If all energy saving measures are applied, it should fall within the range of 100–110 MTOE.

Meanwhile, electricity consumption, which was 54.09 TWh in 2012 [19], would rise, taking into account the impacts of energy efficiency actions, to 120 TWh for a low scenario, to 140 TWh for an average reference scenario, or to 150 TWh for a scenario of high economic efficiency.

As an illustration, the levels of our natural gas needs would fall in 2020 and 2030 respectively to 54 billion m^3 and 102 billion m^3, in addition to the needs of exportation necessary for financing our national economy [15].

3.4.1. New energy strategy

To meet these multiple challenges and better control Algeria's energy future with a view to ensuring its sustainable development, a new energy strategy was developed based on realistic economic and technological options, as part of a clear vision for the future. It has been broken down into concrete action plans that are achievable in the short, medium and long term, accompanied by organizational and regulatory measures to provide the necessary visibility to operators.

In accordance with the directives, the Algerian Ministry of Energy, Mines has identified the strategic options by bringing together national and international experts and all stakeholders in a spirit of consultation, participation and consensus.

Table 18
Sources: API.

Proved reserves	Reserves	Production	Reserves /Production (years)
Crude Oil	1.5	0.086	18
Natural gas	4.1	0.074	55
Totals	5.6	0.162	35

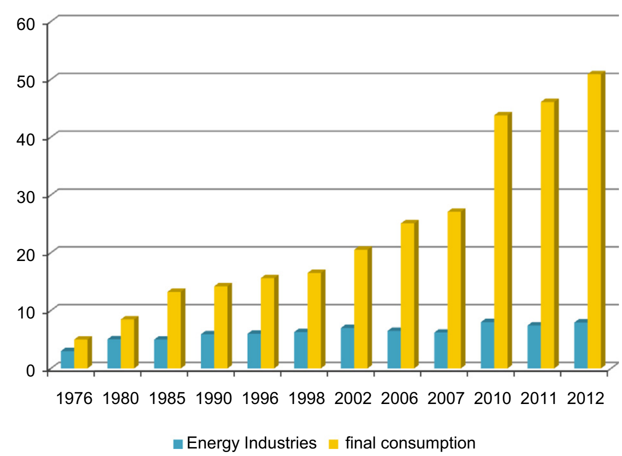

Fig. 4. Evolution of energy consumption (M TOE) [14].

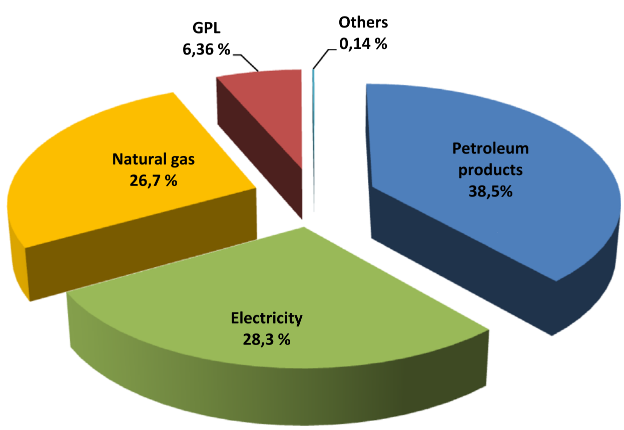

Fig. 5. Distribution of final consumption by product (2012) [14].

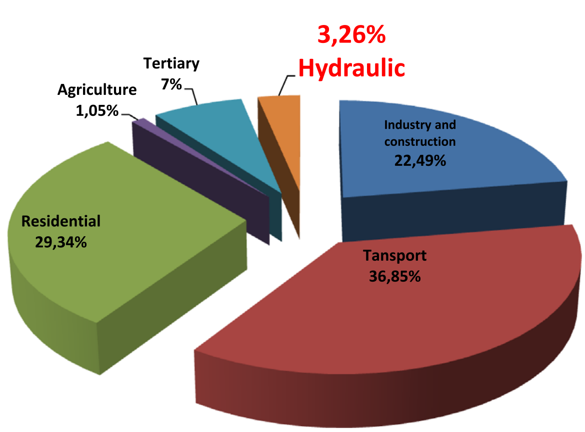

Fig. 6. Distribution of final consumption by sector in 2011 [14].

The strategic objectives are aimed at securing the energy supply, ensuring availability and accessibility of energy at the lowest possible cost and reducing energy dependence by diversifying energy sources, achieved through developing the national energy potential and promoting energy efficiency in all economic and social activities.

Algeria has thus set itself an achievable energy efficiency potential of 12%, to be reached by 2030, and a share of renewable energy in the national energy balance of between 30% and 40%. The overall objective of the program is the installation of 22,000 MW by 2030, 10,000 MW could be dedicated to export.

In this regard, we will now take a more detailed look at the energy sector in Algeria.

3.5. Electricity

In Algeria, the forecast for electricity demand is established by operator system (OS) Sonelgaz Subsidiary.

Based on the country's energy policy, the OS matches supply to demand in two steps:

- An initial step to study electricity demand.
- A second step to define an equipment program in order to satisfy that demand at the lowest possible cost.

3.5.1. Study of the demand

In general, the OS conducts a detailed analysis of past consumption trends (at national level, by sector, by branch, by voltage level, etc.) to shed light on the different factors that determine demand and assess how they effect it.

(1) Retrospective analysis of demand

First, a retrospective analysis of the demand is developed. Generally, a 20-year period is considered for the analysis of overall electricity consumption in order to detect an overall trend and variation in average annual growth. This variation is compared to the average rate of economic growth during the study period, and to population growth.

The analysis is based on:

- A calculation of the elasticity of the electricity demand to GDP.
- A comparison of the population trend index, GDP and electricity consumption over the period studied.
- An analysis of electricity consumption per capita, considered as representing the economic and social dynamics in Algeria.
- An analysis of the characteristics of the electricity demand, overall and by sector.

The OS finds that the electricity sector has registered a steady increase in demand over the last decade, due mainly to the increasingly widespread electrification of the country, to government urbanization efforts, to the improvement in household incomes and to the implementation of large-scale infrastructure projects in various regions of the country.

The relevant OS departments examine the fine detail of changes in demand at peak times and seek to highlight the main reasons for these changes, largely caused by a sharp increase in residential consumption.

The OS's electricity sales history is broken down automatically and a customer analysis performed, making a distinction between OS direct clients and distributors' clients (state distribution companies and concession holders). The impact of the different energy saving campaigns and actions is also considered.

Over the last twenty years (1992–2012), overall electricity consumption has more than tripled, far exceeding economic and population growth.

The elasticity of electricity demand to GDP, estimated over this period, is almost two units. Over a period of two decades, the

growth rate of electricity consumption has continuously exceeded GDP and population growth rates, and the difference has become more pronounced since 1998.
For the same period, electricity consumption per capita increased from 721.53 kWh per capita in 2001 to around 1406 kWh per capita in 2012, equivalent to an average annual increase of 6.25%. The graph below traces these developments.
Moreover, between 2002 and 2012, electricity demand increased from 20.53 GWh to 54.09 GWh, reflecting an average annual growth rate of approximately 9.5% (Fig. 7).
It should be noted that this growth has been uneven, however, as illustrated in the graph below: moderate growth between 2000 and 2005, followed by a period of burgeoning demand for electricity from 2006 to 2012, with an annual average of 10% reflecting the economic and social dynamism experienced by Algeria, in particular in terms of increased access to basic infrastructure (Fig. 8).
The peak maximum power demand increased from 3913 MW in 2001 to 8850 MW in 2011 and 10,464 MW by 2013. This represents an average annual growth rate of 8% over the first 10 years (2001–2008) and 12% for the second period (2009–2013). In 12 years, the peak maximum power demand has thus experienced an average annual growth rate of 9.35% (Fig. 9).

(2) Projected electricity demand
Projections of demand are established over long periods and revised for short- and medium-term periods.
For the short term, demand forecasts are automatically revised to reflect the needs expressed by the different client segments, whether direct clients or those of public or private distributors.
For the medium and long term, forecasts of changes in electricity consumption reflect a combination of various types of factor relating to economic activity, demographics, user behavior, technical progress, development of new uses of electricity, the relative market shares of energy and energy conservation.
Planning to incorporate these factors into long-term forecasts is based on a detailed breakdown of electricity consumption into segments, performed as follows:

- An initial distinction between the industrial, service and residential sectors in total consumption;
- Within these areas, further divisions are made, by branch of economic activity (agriculture, manufacturing, etc.) and by use;
- For each branch or use, characteristic technical-economic variables are identified in order to calculate energy consumption (ownership rates, unit consumption of appliances, number of households, neighborhood, etc.).

From this detailed segmentation analysis, the choice of assumptions about changes in characteristic descriptive variables can be used to predict consumption for each branch or use. The consumption forecasts thus obtained for the different segments are then aggregated to arrive at forecasts for each sector.

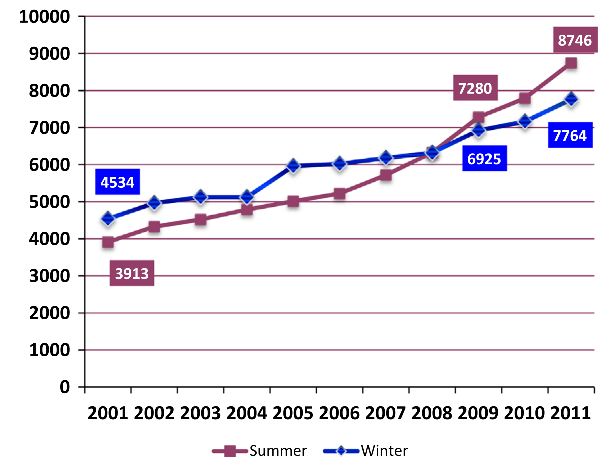

Fig. 9. Electricity demand growth rate trend (MW).

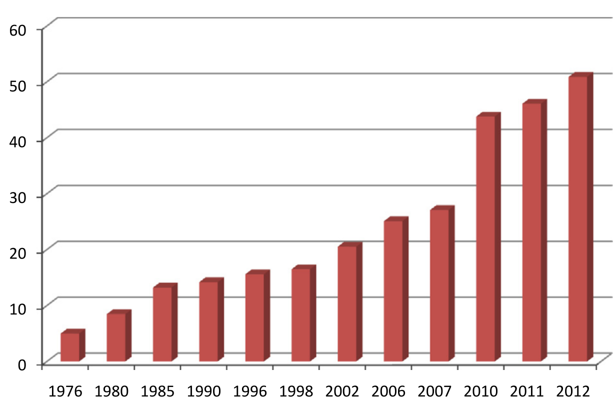

Fig. 7. Evolution of the power consumption (TWh).

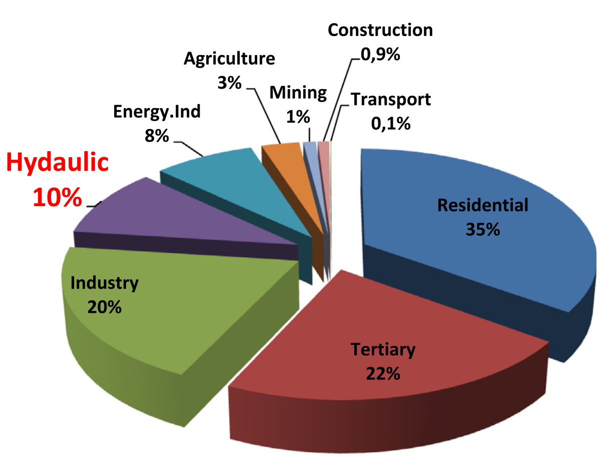

Fig. 8. Distribution of electricity consumption by activity sector "2011".

To guard against the growing uncertainties about changes in the energy and socio-economic environment, three macroeconomic scenarios are considered, selected on the basis of the report from the Algerian High Commission for Planning, entitled ("Economic growth and human development: Elements for strategic planning 2011–2017").

3.5.1.1. By 2017. The "emergence scenario" was adopted as a baseline for developing the equipment plan. This scenario predicts a 7% increase between 2012 and 2017, leading to a net energy demand of 75.79 TWh by 2017. In this scenario, growth is driven mainly by the development of services and tourism in the service sector, and by construction in the secondary sector. Growth in the residential sector is also extremely strong as a result of demographics, urbanization and especially, the development of new specific uses.

The "economic efficiency prioritization scenario" involves an 8% growth rate of net energy demand between 2012 and 2017, resulting in a net energy demand of 79.4 TWh by 2017.

The "exhaustion scenario" predicts a 6% energy increase between 2012 and 2017, limiting consumption to 72.32 TWh in 2017.

3.5.1.2. By 2020. A "segmentation" study, through the identification and consideration of different factors explaining the changes in electricity demand, conducted by Sofreco consultants as part of a

study entitled ("Gradual integration of the Algerian, Moroccan and Tunisian electricity markets in the European Union's internal electricity market") analyses the economic and social contexts that prevailed during the past period and plausible future changes for Algeria, in the light of its potential but also regional and international opportunities and constraints.

The study was set in the context of the scenarios mentioned above. Each of these identifies a plausible situation that could describe possible future electricity consumption trends.

These three scenarios were constructed based on the determining factors considered as explanatory of the electricity consumption of the different sectors.

Thus, the emergence scenario is characterized by 6% annual growth between 2017 and 2020; the economic efficiency prioritization scenario would involve an annual growth rate of net energy demand in the region of 7.2%; the exhaustion scenario would see an average annual increase of 5.2%.

3.5.1.3. By 2030. It is assumed that by 2030 a form of saturation will have occurred in a number of sectors of economic activity, that consumption in the residential sector will have stabilized and that tangible effects of the energy efficiency policy will be felt throughout the country.

At this point, then, the emergence scenario would be limited to growth of 4.2% per year; the economic efficiency prioritization scenario, 5.5% per year and the exhaustion scenario would not exceed an average annual rate of 3.5%.

The growth in consumption at the various dates quoted above is summarized in Table 19.

3.5.2. Study of the supply

The aim is to develop a production facilities equipment program in order to meet, at minimum cost and according to predefined quality and continuity of service criteria, changes in demand.

The development of the equipment program takes account of:

- The continued development of national primary energy resources;
- The diversification of external fuel supply sources;
- The quest for greater energy efficiency.

It is determined by minimizing the sum of the following discounted costs:

- Investment costs;
- Operation and maintenance costs;
- Fuel costs;
- Cost of energy not served.

It takes into account a number of constraints and criteria, including:

- Satisfaction of priority irrigation and drinking water needs;
- Satisfaction of energy demand;
- Monitoring fluctuations in power demand (load curve);
- Planned and unplanned outages;
- The reserve margin.

3.5.2.1. The electric power supply. In late 2011, the total installed capacity of the generating facilities was estimated at **11389.8** MW. The park existing at that date is detailed Table 20.

The installed capacity increased from 1852 MW in 1980 to 5600 MW in 2001, peaking at 11 389.8 MW in 2011. This resulted in an average increase in capacity of 178.5 MW per year between 1980 and 2001, and of around 526.35 MW per year between 2001 and 2011. The additional capacity changes in increments that are easier to view in Table 21.

3.5.2.2. New electricity strategy. The Algerian power sector is facing many challenges related to security of supply, diversification of energy sources, organizational and legal aspects as well as strategic planning.

For this reason and in accordance with the country's royal directives, the Ministry of Energy, Mines, Water and the Environment named the electricity sector as one of its major concerns to be addressed as part of a vision for the future, the aim being to set as a priority, the adoption of an electricity policy that will generate action plans designed on the basis of a clear vision for reform. These plans are broken down into concrete measures and feasible projects. The overall aim is to ensure a competitive power supply in the service of the national economy at all times.

The Ministry of Energy and Mines has involved a broad range of national and international experts along with all stakeholders, to develop documented, widely-shared visions of four elements that constitute the foundations of the national power strategy:

- Changes in domestic demand, and potential major discontinuities.
- The advantages and constraints specific to Algeria.
- The economic and technical characteristics of the available power generation technologies.

3.5.3. New opportunities

(1) Considerable solar resources
- With more than 3600 h per year of sunshine, equivalent to irradiation of 6 kWh/m^2 per year, Algeria has a high solar capacity (average equivalent to Southern Europe).
- Especially high potential in underserved areas in terms of grid and power production capacity.
- Particularly attractive cost (9% below the reference cost). Fig. 10.

Table 19
Projected electricity demand in TWh.

Date	2012	2017	2020	2030
Exhaustion scenario	54.04	72.32	93.18	110.67
Emergence scenario	54.04	75.79	101.42	124.58
Efficiency scenario	54.04	79.40	112.40	146.90

Table 20
Distribution of total electricity production in 2011.

Type of equipment	Production GWh	Rate %
Steam turbine	9653.7	19.8
Combined cycle	15,701.3	32.1
Gas turbine	22,055.3	45.1
Hydraulic	378.3	0.8
Diesel	463.9	0.9
Hybrid site	618.7	1.3
Total	**48,871.2**	**100**

Table 21
Changes in installed capacity.

Capacity of production (MW)	1980	1990	2001	2010	2011
Sonelgaz (SPE)	1852	4567	5600	8446	8503.8
Independent	–	–	–	2886	2886
Total	1852	4567	5600	11,332	11,389.8

(2) Significant wind resources
- A wind power potential of 2.025 MWh/m^2/year at the sites studied.
- Extensive distribution throughout the country, for supplying remote, off-the-grid areas (Fig. 11).

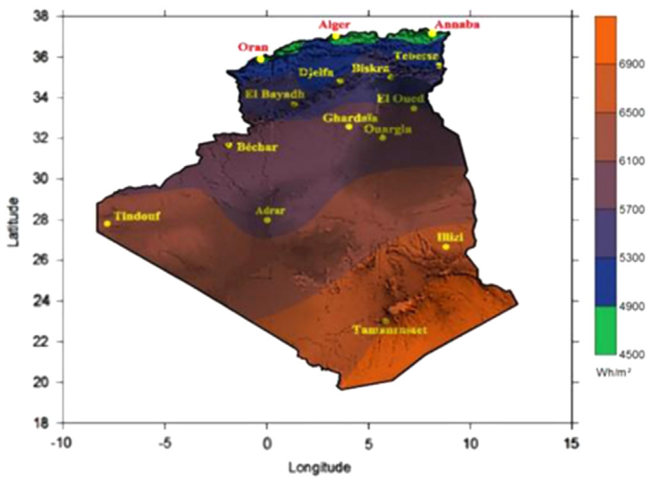

Fig. 10. Average annual irradiation in Algeria.

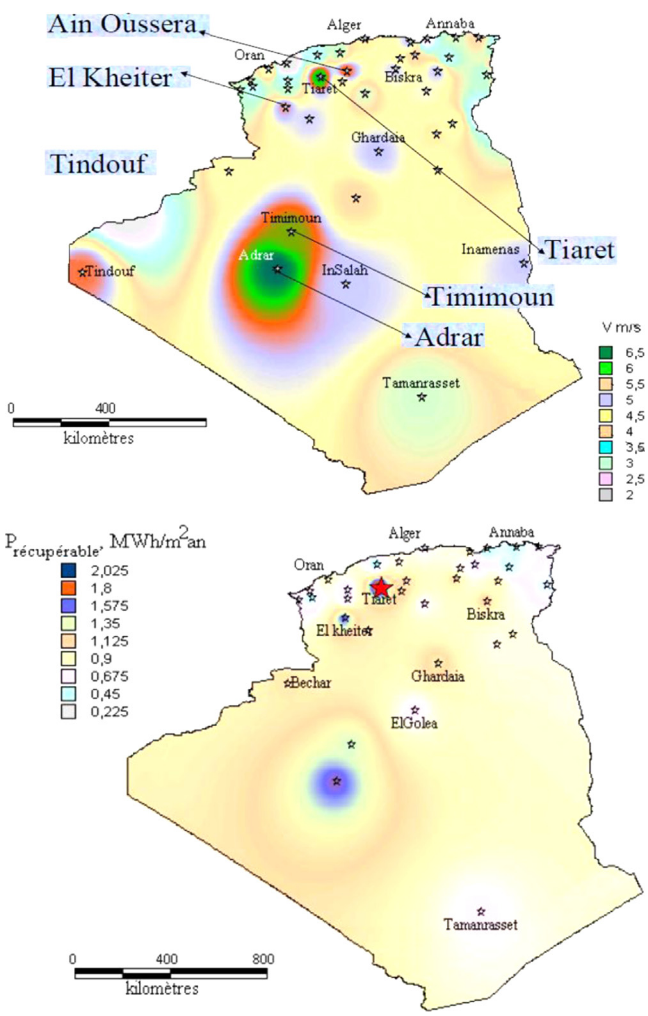

Fig. 11. Annual eolian potential and speed of wind in Algeria [21].

(3) Geographical positioning between two major markets: attractive arbitrage opportunity for Algeria.

3.5.4. Meeting demand

3.5.4.1. Meeting demand for 2013–2017. To meet the demand for electricity, Sonelgaz has programmed an additional power of 8050 MW by the realization of projects listed in Table 22.

In addition to this power there are other projects already decided and their tenders have been launched (Table 23), (Fig. 12).

3.5.4.2. Meeting demand beyond 2018 [20]. The additional capacity planned for the period 2013–2023 will amount to 35,505 MW of which 21,305 MW are decided and 14,200 MW in project idea (conventional type) [20].

The 21,305 MW already decided consist of:

- 539 MW of renewable energy,
- 14,370 MW of conventional for the interconnected North grid (ING),
- 50 MW of gas turbine to In Salah - Adrar - Timimoun,
- 421 MW of gas and diesel turbines for isolated south grid (ISG).
- 925 MW for strategic mobile reserve.

The total development program for the production of electricity 2013–2023 will amount to more than 4,791,391 million dinars (more than 2,664,878 million dinars for renewable).

14,370 MW of additional capacity are under construction on the 2013–2017 period, of which 1140 MW of Koudiet Eddraouech site (SKD).

Additively to a conventional park, it is expected the realization by SKTM (Shariket Kahrabaa el el li Takat Moutadjadida, subsidiary of Sonelgaz group) of a renewable energy park of 5539 MW distributed as follows:

- Interconnected Grid of North (IGN): 5084 MW of renewable energy planned for the period of 2013 to 2023 which can be carried out in collaboration with the SSB (Sahara Solar Breeding) project for example.

Table 22
Projects 2013–2017.

Planned sites	Combined cycle [MW]	Gas turbine [MW]	Total [MW]
West region			
Mostaganem (New site)	800	400	1200
Naama (New site)	800	400	1200
Boutelilis (extension)	300	–	300
Total	1900	800	2700
Center region			
Hadjret Ennous (new site)	800	400	1200
Djelfa (new site)	800	400	1200
Boufarik (MAPNA) (extension)	–	300	300
Total	1600	1100	2700
East region			
Kaïs (new site)	800	400	1200
Biskra (new site)	800	400	1200
Ain Djasser (extension)	–	250	250
Total	1600	1050	2650
Total General			
West	1900	800	2700
Center	1600	1100	2700
East	1600	1050	2650
Total	5100	2950	8050

Table 23
Projects 2013–2017 -continuous.

Site	2013	2014	2015	2016
Labreg (GT)	1 × 171 MW GT	2 × 171 MW GT		
Ain Djasser 2 (GT)	2 × 132 MW GT			
Boutlelis (TG)		2 × 258 MW GT		
Hassi Messaoud (GT)			4 × 150 MW GT	
Hassi R'Mel (GT)			2 × 150 MW GT	
Ras Djinet 2 (CC)				3 × 400 MW CC
Ain Arnat (CC)				3 × 400 MW CC
Total [MW]	435	858	900	4400

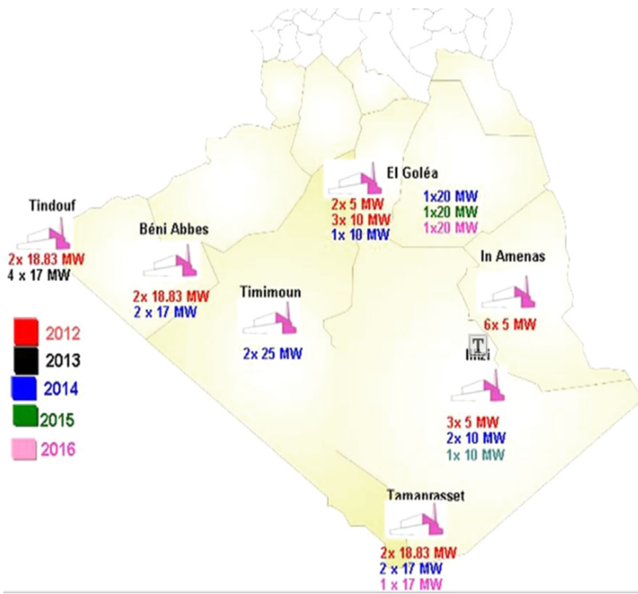

Fig. 12. Sites in progress of realization in the south of Algeria.

- Isolated Grid of South (IGS): 167 MW of renewable energy planned for the period of 2013–2023.
- InSalah - Adrar - Timimoun: 288 MW of renewable energy planned for the period of 2013–2023.

Beyond 2023, the various types of electricity generation will be investigated and the necessary decisions will be taken at the appropriate time, wind farms, solar farms, natural gas power plants or even the hydroelectric sites.

For Renewable Energy [18].

Until 2030, it is planned to install a capacity of nearly 12,000 MW with 10,000 MW of export opportunity.

The development of renewable energy is a major component of Algeria's new energy strategy, aimed at securing supply, ensuring availability and reducing the nation's energy dependence.

Algeria has great renewable energy potential. Exploiting it will cover a substantial part of its growing energy needs and help protect the environment by replacing fossil fuels.

The contribution of renewable to the energy mix will expand gradually, as the technologies mature and their production cost becomes more competitive.

3.5.5. International trend

A favorable world market:

- An environment conducive to the development of renewable energy.

Table 24
Annual flows of investment in Renewable Energy technologies.

	2003–2010	2010–2020	2020–2030	2030–2040	2040–2050
Hydro	41.7	34.1	24.7	24.1	20.6
Wind	19.8	79.4	84	36.7	41.6
Photovoltaic	11	35.2	79.4	78.3	77.3
Thermal solar	0.7	11.3	43.6	49	49.7
Marine	1.1	2.8	2.7	3.1	2.7
Total	74.3	162.8	234.4	191.2	191.9

- Technologies in continual development, tending to reduce investment and operating costs and produce competitive kWh or Btu.
- Uncertainty and extreme volatility of fossil fuels.
- Environmental awareness and the fight against global warming.
- A competitive cost per MW for some renewable (including wind) and a downward trend in the medium- and long- term for others.
- A high-potential market for: wind, solar thermal and photovoltaic.
- More than US$ 60 billion invested in 2007 in renewable energy projects worldwide5.
- A CO_2 emissions market of approximately US$ 233 billion in 2050 (compared to US$ 60 billion in 2007).
- The total installed capacity in late 2007, all segments combined, was estimated at around 240 GW, excluding large-scale hydropower, equivalent to nearly 6% of global electricity capacity.
- Wind farms in 2007 totaled almost 100 GW, with average annual growth of 25%.
- 50 million households worldwide have solar water heating systems, 65% of which are in China. The annual growth in this market is between 15% and 20%.
- 2 million geothermal heat pumps installed.
- Grid-connected solar photovoltaic is growing constantly.
- Biodiesel generation is under development.

The annual flow of investment in "Renewable Energy" technology per period in billions of USD6 is (Table 24):

(1) Constraints to developing renewable energy

Current situation

- Capacities for developing renewable energy projects extremely limited compared to identified potential.
- Marginal contribution of foreign funds.
- Limited government incentives.

Constraints

- Lack of legislative and regulatory framework concerning the development of renewable energy.
- Renewable energy low on the priority lists of national infrastructure development programs.

- Competition from subsidized energy sources: e.g. butane and fuel oil.
- Low level of information and awareness among general public.
- Lack of research and development that could lead to innovation and technological adaptations.
- "Project" approach not creating visibility for potential investors or deployment of suitable financial mechanisms.
- Budget allocations and financial incentives insufficient for real development of the economic, social and environmental added value of renewable energy.

(2) Renewable energy development strategy

The new energy vision is structured around the following points:

- Renewable energy: a major aim of the New Energy Strategy.
- A diversified national energy mix aimed at developing renewable energy on a market basis using 4 strategies:
  – Progressive development of Power Purchase Agreements (PPA)
  – Promotion and development of large-scale projects for exporting green power.
  – Development of self-production.
  – Strengthening the capacity of the grid.
  – Contribution to reducing energy dependence.
  – Controlled expansion of energy resources to support economic development.
  – Positioning Morocco in regional and international renewable energy and energy efficiency markets.
  – Development of a renewable energy equipment and facilities industry.

(3) The objectives of the new strategy

- Contribution to diversifying and securing supplies.
- Sustainable human development: widespread access to energy and creation of income-generating activities.
- Control of energy costs to ensure the competitiveness of domestic production.
- Optimization of the electric load curve.
- Environmental protection: control of growth in greenhouse gas emissions, 60% of which is from energy production.
- Conservation of natural resources: water, forest cover, biodiversity, combating desertification.
- Economic development and investments.
- The industrial rise of a new sector, regional positioning to win.
- Increased mobilization of international cooperation and strengthening regional partnerships (Euro-Mediterranean, African, and Arab).

4. Energy needs for water

Electrical energy is used mainly for the operation of pump and injection stations for drinking, industrial and irrigation water, drinking water treatment plants and activated sludge wastewater treatment plants. It is also used for lighting and for pumping in marine outfalls (Fig. 13).

Overall, the water sector in 2011 consumed around 4983 GWh. This consumption is set to rise to 16,090 GWh by 2030 (0.7–0.8 kWh/m^3), more than three times the consumption of 2011. This predicted increase is mainly due to:

- The use of energy-intensive solutions – e.g. sea water desalination and the water transfer project.
- Use of conventional, high energy-consuming resources in order to meet water demand. This is the case of water pipes for drinking water supplies the cities.

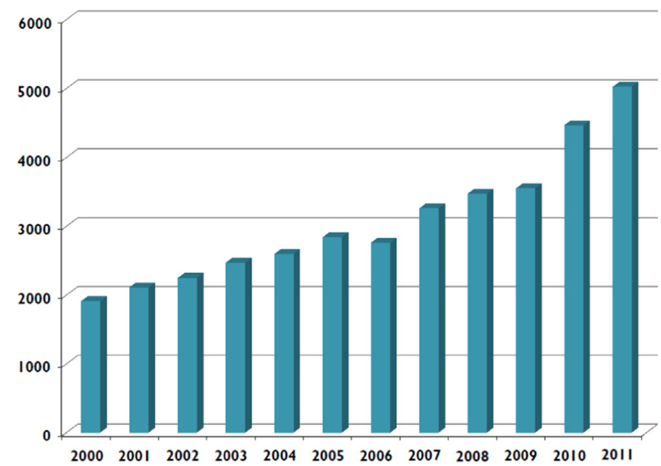

Fig. 13. The evolution of consumption in GWh [13].

- Development of sanitation and wastewater treatment activities (Table 25).

4.1. Current need

These needs, collected from water users, seem to be in the region of 4983 GWh, or 0.44 kWh/m^3.

4.2. Energy needs by 2030

These energy requirements were evaluated on the basis of current needs and the provisions adopted regarding usage of conventional and unconventional water resources, water saving programs, drinking water generation programs, sanitation and wastewater reuse programs, and programs aimed at water conservation and expansion of irrigation.

4.2.1. Drinking water

Energy requirements were estimated on the basis of current needs and drinking water supply projects adopted in connection with planning studies. These energy needs are estimated at around 2606 GWh, or 0.90 kWh/m^3:

- Sea water desalination, these needs are estimated at approximately 1642 GWh, or 3.7 kWh/m^3.
- Use of energy-consuming drinking water supply systems.

4.2.2. Sanitation

Electrical energy is used mainly for the operation of activated sludge wastewater treatment plants (in lagoon-based wastewater treatment plants (WWTPs) it is used for pumping and sometimes for treatment), for network pumping and for lighting. It is also used for pumping in marine outfalls.

The electrical energy estimate is based on the following assumptions:

- The activated sludge purification process was adopted for WWTPs serving more than 100,000 inhabitants. The power consumption for these WWTPs was calculated on the basis of 1 kWh/kg BOD5 eliminated.
- The lagoon-based purification process was adopted for all other towns and cities. The power consumption for these WWTPs is negligible. The national sanitation plan has estimated this

Table 25
Evolution of energy consumption in the water sector.

Sector	2011		2030	
	Water (Mm^3)	**Energy (GWh)**	**Water (Mm^3)**	**Energy (GWh)**
Drinking and industrial water (with desalination)	2900	2606	3500	5700
Irrigation	8600	1513	15,400	9193
Sanitation	1000	331	1200	397
Wastewater reuse	800	533	1200	800
Total	12,300	4983	20,100	16,090

consumption at around 10% of the consumption of WWTPs that use activated sludge.

On this basis, the national water plan estimated the energy requirements for sanitation and wastewater treatment at 397 Gwh by 2030.

This data does not take into account energy needed for wastewater reuse (additional treatment, pumping water to the place of use, etc.).

4.2.3. Irrigation

Overall, the water needs of the agricultural sector are estimated at around 9193 GWh per year. The assumptions used in estimating these water needs can be summarized as follows:

- Current (2011) energy needs of agricultural areas are estimated at about 1513 GWh per year.
- The energy requirements of extensions to agricultural areas,

4.2.4. Wastewater reuse

Overall, the energy requirements of wastewater reuse projects are estimated at around 800 GWh, or 0.7 kWh/m^3.

The assumption used to estimate this need is:

- Reusing a volume of treated wastewater in the region of 1200 Mm^3 per year for watering golf courses and green spaces as well as for irrigation of those crops that are suited to it.

5. Conclusion

In order to cope with population growth and economic development, energy and electricity demand in Algeria will increase substantially between now and 2030.

In the absence of a rigorous energy efficiency policy, the energy sector's water requirements will be also envisaged in terms of electricity generation in hydroelectric plants (dams), as make-up water for cooling in classic thermal power stations, and cleaning for the hybrids stations (solar-stream) particularly for those located in the country's interior (Sahara).

Annexes

See Table A1.

Table A1
Trend scenario of water and energy sectors.

	2011	**2030**
Water demand **(Mm^3)**	12,300	20,100
Electricity demand for water **(GWh)**	4983	16,090
Total electricity demand **(GWh)**	48,860	146,900
Natural gas reserves (years)	52	33
Oil reserves (years)	15	0

References

[1] Surface water resources mobilization; document of Algerian Ministry of Water Resources; February 2012.
[2] Underground water resources mobilization; document of Algerian Ministry of Water Resources; February 2012.
[3] Program of desalination, large and small stations. DAEP 02/10/2012.
[4] The action plan 2010–2014; mobilization and demineralization of brackish. Document of Algerian Ministry of Water Resources; September 2012.
[5] Note on the work of agricultural hydraulics; document of Algerian Ministry of Water Resources; September 2012.
[6] Indicators in drinking water; document of Algerian Ministry of Water Resources; January 2013.
[7] Updating the inventory of national sewerage network; document of Algerian Ministry of Water Resources; September 2012.
[8] Agricultural Water; document of Algerian Ministry of Water Resources; September 2012.
[9] Profil fourrager, Dr D. Nedjraoui, (USTHB); janvier 2001.
[10] State details of irrigated operating perimeters; document of the Ministry of Water Resources; Sept 2012.
[11] The efficiency of water use and economic approach; National Study Algeria, Mohamed Benblidia, Sophia Antipolis in June 2011.
[12] Strategy and indicators of water sector in Algeria, presentation of Algerian Ministry of Water Resources in Cairo; 21–22 November 2012.
[13] Energy Efficiency in the use of hydraulic systems, presentation of the national agency for the promotion and rational use of energy, International Symposium of the 9th edition SIEE-Pollutec; May 2013.
[14] National Energy Balance of 2012, Algerian Ministry of Energy and Mines, 2013 edition.
[15] 〈https://portail.cder.dz/spip.php?article1155〉.
[16] Cherfi Souhila; Energy future of Algeria, Faculty of Economics and Commercial Sciences and Management Sciences; University of Mohamed Khider-Biskra; Juin 2011.
[17] Attar et M, Hammat M. The hydrocarbon potential of Algeria, document of CHLUMBERGE-SONATRACH; 2011.
[18] Program of renewable energy and energy efficiency, document of Algerian Ministry of Energy and Mines, design and realization by SATINFO (Sonelgaz); March 2011.
[19] Activities report and management accounts consolidated of Sonelgaz; 2012.
[20] 〈http://www.sonelgaz.dz/?page=article&id=13〉. Copyright © SONELGAZ; 2013.
[21] Kasbadji Merzouk N, Merzouk Mr. Prospect of wind pumping. Algiers: CDER Bouzaréah Algeria; 2011.
[22] 〈http://www.abhs.dz/php/fr/contacts.php〉.